A STUDY ON THE EXECUTIVE FUNCTIONS OF YOUNG CHILDREN

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Abstract

The main aim of the present study is to study the executive functions of young children. In this study, qualitative approach was used. The participants were 5 children (age 4-10) from Katha Township. Observation, reflection and performance-based tasks were used as the instruments in this study. The performance-based tasks are divided into three tasks; (a) Completion of mazes to measure working memory skills, (b) Head-Thigh-Toe (HTT) task to measure inhibition skills, and (c) Tasks that require sorting cards based on various criteria to measure cognitive flexibility (shifting) skills. The overall results showed that (4-10) year-old children's executive functions start to develop and can be improved as much as they can. And then, there was no general pattern based on age or gender. This is an important finding because it highlights that difference in executive functions is not necessary due to age or gender.

Keywords: Executive Functions, Inhibition, Cognitive Flexibility, Working Memory.

Introduction

Executive functions (EFs) are the cognitive abilities that control and regulate most of what we do in day to day life (Diamond, 2013). Executive functions are not only an essential component of self-regulation (Moffitt et al., 2011) but also broadly applied across a wide range of daily-life activities (Diamond, 2013). Executive functions are the staple of every students' learning. These are like any other skills and can be improved with training and exercises (Lee & Shute, 2010).

Executive functions play both direct and indirect parts in classroom learning. Executive functions design to help students sit still, pay attention, recall and follow rules, and flexibly adopt new perspectives. Children who well-practiced executive functioning skills may learn more easily, and this may initiate a positive cascade of indirect effects, such as preferring school and being motivated to work hard and get along with educators and peers. Differently, weak executive functioning skills may intervene with children's own (and others') learning and may lead to behavior problems, suspension, expulsion, or being held back (U.S. Department of Education, 2014). So, parents and educators should pay special attention to the importance of executive functions and promote these vital skills from early childhood for future success.

Purposes of the Study

The main aim of the present study is;

- to study the development of the young children's executive functions.

The specific objectives are;

- ✓ to examine the development of executive functions of young children by gender.
- ✓ to examine the development of executive functions of young children by age.

Definitions of Key Terms

Executive Functions : Executive functions are the cognitive abilities that control and regulate most of what we do in day to day life (Diamond, 2013).

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Inhibition : Inhibition is the ability to focus on the information that are important or relevant to the task and ignoring or inhibiting distractions or behaviors that are not important or relevant to task (Miyake et al., 2000).

Cognitive flexibility : Cognitive flexibility refers to shifting one's attention between or otherwise managing multiple tasks, goals, rules, or perspectives (Miyake et al., 2000).

Working memory : Working memory involves holding and working with information in one's mind (Miyake et al., 2000).

Review of Related Literature

When considering and understanding the various individual executive functions, discussion of the development of these skills is imperative. Levine (2002) had broken down development of executive functions into four periods: (1) preschool through first grade, (2) grades 1 through 3, (3) grades 4 through 8, and (4) adolescence.

There is a growing body of research that suggested executive functions develop substantially during the school years (Romine & Reynolds, 2005) with seeds being planted early in the preschool years (Best et al., 2009) that will become more fully developed in the later years. And then, Holler and Greene (2010) had described the development of executive functions as beginning even before birth.

According to Piaget's cognitive development model, 2 to 7 years old is the pre-operational stage. In this stage, object permanence is firmly established and symbolic thoughts develop. And then, 7 to 11 years old is the concrete operational stage. In this stage, the child can understand the principle of conservation, can use to manipulate, transform and then return an object to its original state.

Although the construct of executive functions was first introduced by Luria in 1966, theoretical consensus about the construct has been slow to develop. According to Luria (1966), the brain consists of three functional units, and it is the third unit in which EFs mechanisms operate. The first functional unit is located mainly in the brain stem and is responsible for regulating and maintaining arousal of the cortex. The second functional unit is responsible for encoding, processing, and storage of information and encompasses the temporal, parietal, and occipital lobes. The third functional unit is located in the anterior region of the brain (frontal lobes) and its functions include programming, regulating, and directing behavior. Within the third unit, the prefrontal cortex is considered by Luria as a superstructure that regulates or controls mental activity and behavior.

Developmental theorists have constructed theoretical frameworks of executive functions that delineate the component as having different developmental trajectories. Diamond (2006) supported a componential view of executive functions development, noting that working memory, inhibition, and cognitive flexibility (shifting) show different developmental trajectories and are unique sub-components in children ages 3-6 years old. Core executive functions (EFs) include inhibition (controlling one's behavior, attention, thoughts, emotions), working memory (temporarily holding and using information), and cognitive flexibility (effectively switching between tasks) (Diamond, 2013; Zelazo et al., 2013; Miyake et al., 2000).

Inhibition is the ability to focus on the information that are important or relevant to the task and ignoring or inhibiting distractions or behaviors that are not important or relevant to task (Miyake et al., 2000). Inhibition is a foundational executive function (EFs)—it allows students to control dominant responses in their attention, thoughts, emotions, and behaviors, and do what is right to meet the task and context demands. An example in a classroom context is overcoming the desire to blurt out an answer without raising one's hand. Older children utilize inhibition to

rally their attention to the task at hand, even when the task is not intrinsically interesting. For example, they curb the desire to pursue competing interests, such as getting on Facebook, rather than completing an online study quiz. Working memory involves holding and working with information in one's mind (Miyake et al., 2000). Working memory entails simultaneously storing and processing information. In mental math, for example, students have to keep two numbers in mind, bring to the forefront of their memories the rules for multiplication, use all this information to make the calculation, and generate a solution. As such, working memory underlies reasoning and problem solving. Cognitive flexibility, or the ability to shift mental sets, allows students to manage changing demands in classrooms. Cognitive flexibility refers to shifting one's attention between or otherwise managing multiple tasks, goals, rules, or perspectives (Miyake et al., 2000). At the simplest level, cognitive flexibility enables students to seamlessly switch between classroom activities—from individual note taking to collaborative problem solving. Cognitive flexibility also enables applying novel strategies to the task.

Method

Sampling

The participants were 5 children (age 4-10) from Katha Township. They are 5 children in the sample: one 4 year old male, one 5 year old female, one 6 year old female, one 8 year old male and one 9 year old male.

Research Method

In this study, qualitative approach was used.

Research Instrumentation

Observation. Wragg (2002) also noted that observations can take a qualitative lens that "[tells] the whole story" not just the frequency of an event. Gestures, movement, body language can all be an important part of the classroom (Wragg, 2002). The researcher observed children in the classroom for the following categories related to executive functions: inhibitory control, working memory, and cognitive flexibility. As each child was observed, the specific dialogue, expressions, interactions, and behavior were recorded. Some relevant pictures of the children were also taken as they related to the three categories.

Within the observation session, which typically was an hour to an hour and half, the researcher attempted to observe each participant for five to twenty minutes. While observing the participant, the researcher observed for the three components of executive functions and then recorded the details of each behavior. The time was not held constant for each participant. When the researcher observed a participant, the aim was to watch an entire event or process. In some cases, this meant that a participant was observed for 10-30 minutes.

Reflection. As observation were documented, the researcher spent time writing down reflection on patterns and thoughts about the daily and weekly observation in a reflective journal throughout the study. This is an important aspect of the qualitative study as insights and emerging patterns were tracked throughout the study.

Performance-based measures with tasks that tap core Executive Functions. There are many performance-based measures with tasks that tap core executive constructs. Among them, the researcher chooses the suitable three tasks. They are; (a) Completion of mazes to measure working memory skills, (b) Head-Thigh-Toe (HTT) task to measure inhibition skills, and (c) Tasks that require sorting cards based on various criteria to measure shifting skills.

Qualitative Data Collection Procedure

Observation. After gaining consent from the parents, the researcher began observation in the following categories for executive functions: working memory, inhibitory control, and cognitive flexibility. Over a five week period, the participants were observed from an hour to an hour and half. The researcher spent on average four to five hours per week during the morning hours of the days observing five children. The details of the participant's behavior as well as any dialogue, actions, facial expression were recorded as well as any pertinent pictures were taken of the participants in observation sessions by using checklist related to the three constructs of executive functions.

Reflection. After the observation session, reflective journal for any personal observation and thoughts were documented. Throughout each day, any observation from the environment were noted concerning the children's behavior and recorded reflection for later use. This is an important aspect of the qualitative study as insights and emerging patterns were tracked throughout the study.

Performance-based measure with tasks that tap core Executive Functions. (a) Completion of mazes procedure. When completing the maze, participants are expected to trace and complete a maze without crossing the maze line, backtracking or going over the same path twice, or entering a dead-end of "blind alley". If these requirements are at any point violated, the participants are given a new copy of the same maze to complete but for a reduced score. The participants are expected to complete a certain number of mazes, all of which increase in difficulty as the test progresses.

(b) Head-Thigh-Toe task procedure. The researcher used a revised version of the Head-Thigh-Toe (HTT) task considering its difficulty level for young children. The Head-Thigh-Toe (HTT) task, modified from the Head-Toes-Knees-Shoulders task (HTKS) to adjust the level of difficulty for children was administered to examine children's inhibition. This task has been successfully used to measure inhibition in preschool and primary school children (Chung, 2015).

Children were instructed to perform 'unnaturally' in response to three paired behavioral commands. For example, children were required to touch their toes when they heard the command to 'touch your head;' to touch the head when they heard the command to 'touch your thigh;' and to touch their thigh when they heard the command to 'touch your toes.' Feedback was only given for the practice items. The test commands were presented in a random order and the children were asked to respond as fast as they could. Children received two points for a correct response; one point for a self-corrected response; and zero points for an incorrect response.

(c)Tasks that require sorting cards based on various criteria procedure. Card sorting is a great, reliable and inexpensive method for finding patterns in how users would expect to find content or functionality, the cards sorting is usually used in young children (Frye, Zelazo, 1995). Those patterns are often referred to as the users' mental model.

There are two primary methods for performing card sorts. In open card sorting procedure, participants are given cards showing site content with no pre-established groupings. They are asked to sort cards into groups that they feel are appropriate and then describe each group. Open card sorting is useful as input to information structures in new or existing sites and products.

In closed card sorting, participants are given cards showing site content with an established initial set of primary groups. Participants are asked to place card into these pre-established primary groups. Closed card sorting is useful when adding new content to an existing structure, or for gaining additional feedback after an open card sort. This task measures the ability to integrate feedback as the rules and requirements of tasks often change and a shift in mental set is required.

Findings

Throughout the five weeks of observation, reflection, pictures and performance-based tasks were gathered and organized to gain a better understanding of pattern in the research procedure. The qualitative observation were typed into word documents by individual each week to aid in content analysis by using Hyper Research 450 Qualitative Analysis Software. The performance-based tasks were organized into five individual charts by Executive Functions constructs. The researcher ensures reliability and validity in the data analysis and in the findings by using Hyper Research 450 Qualitative Analysis Software. And then, the researcher generalized an overview of the final steps.

(a) Reflection for the Observation (Word Documents for Content Analysis)

Child 1

1. Child 1 thinks and acts before doing something.
2. Child 1 speaks and acts fluently based on various conditions and also know various things.
3. Child 1 can clearly explain the rules of the games when playing with friends.
4. Child 1 knows what to do and what not to do to get a job done.
5. Child 1 can do something from start to finish. (E.g., painting, drawing, building blocks, sorting cards and etc.)

Child 2

1. Child 2 first thinks about what to do before doing a tasks.
2. Child 2 can be categorized into the same and different things.
3. Child 2 can have fun playing rules games with friends.
4. Child 2 works until a task is completed.
5. When child 2 is asked something by the adults, he is able to respond accurately to the subject matter, he also knows how to do to complete the tasks.

Child 3

1. Child 3 often thinks and asks adults what he does not understand how to start the tasks and asks until he understands.
2. Child 3 can be categorized into the same and different things.
3. Child 3 can also play games with rules.
4. Child 3 can also complete the tasks.
5. Child 3 repeats a task over and over until it is completed.

Child 4

1. Child 4 is a good listener to her parents, adults and friends and always thinks the tasks before she acts.
2. Child 4 can also distinguish between similarities and differences of objects or conditions.
3. Child 4 also plays games with rules.
4. Child 4 also works until the job is done.
5. Child 4 is sure to get the job done step by step.

Child 5

1. Child 5 tends to focus on tasks.
2. Child 5 can also be categorized into the same and different things.
3. Child 5 can also pay clear instruction for the rules of the games when playing with friends.

4. Child 5 is able to do something successfully.
5. Child 5 can prepare for the task at hand to get the job done.

(b) Findings for Content Analysis of Observation

The results of the content analysis for the reflection of the observation by using Hyper Research 450 Qualitative Analysis Software are shown in the following frequency graph and pie chart: facts from the text document are represented and correlated in the form of frequency expressed as an actual number of the main constructs of Executive Functions. According to the results of content analysis, the mean percent of cognitive flexibility, inhibition and working memory are 28%, 46% and 26% respectively. So, the result has shown that selected (4-10) year-old children are most likely to use inhibition skill (46%).

Table 1 Frequency Analysis for Content Analysis of Observation

Executive Functions	Total	Min	Max	Mean	*SD*	Mean %
Cognitive Flexibility	10	10	10	10	0	28%
Inhibition	16	16	16	16	0	46%
Working Memory	9	9	9	9	0	26%

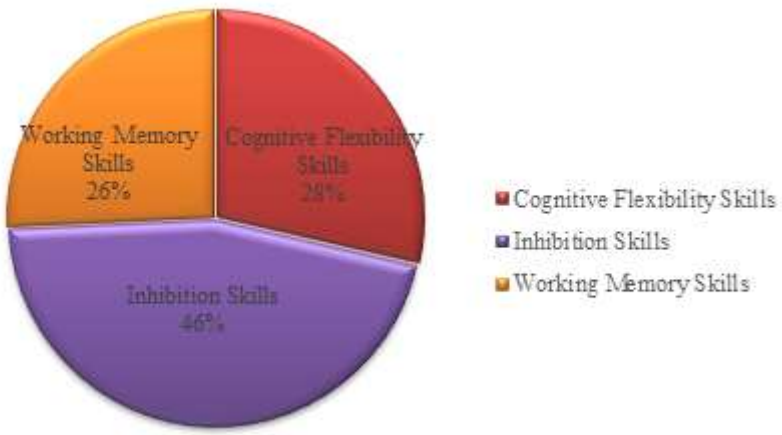

Figure 1 Pie chart for Content Analysis of Observation

(c) Findings for Inhibition Task

Sample	**Inhibition (Head-Thigh-Toe)**
Child 1	Sufficient attention, respond as fast as he can, get correct respond.
Child 2	Comfortable feeling, respond correctly in order to instruction.
Child 3	Special attention, repeated practice, get correct respond.
Child 4	Repeated instruction, complete the tasks with support, special attention.
Child 5	Sufficient attention, respond the tasks' instruction conveniently.

(d) Findings for Cognitive Flexibility Task

Sample	**Cognitive Flexibility (Sorting cards)**
Child 1	Sorting the cards according to the rules and requirements of tasks completely (e.g., shape or color).

Sample	Cognitive Flexibility (Sorting cards)
Child 2	Based on various criteria, sort the cards so fast.
Child 3	Sufficient sorting skills based on various criteria.
Child 4	Sorting the cards according to the rules and requirements of tasks completely.
Child 5	Based on various criteria, sort the cards so clever.

(e) Findings for Working Memory Task

Sample	Working Memory (Completion of mazes)
Child 1	When child 1 crosses the alley to the destination, he first uses his/her index finger to try to reach the goal without drawing pencil. If he/she has a clear idea of the path, child 1 can use the pencil to get to goal only. So that the tasks can be completed without error.
Child 2	Child 2 goes first with the intention of reaching the goal. Then draw and trace a line to the goal using a pencil. Child 2 can also carry out the tasks smoothly.
Child 3	Child 3 uses the first pencil to draw the path at once, but the path is blocked and a new duplicate is obtained. Because child 3 was careful not to make another mistake, he carefully guided the path and reached for it with a pencil, so the task was successful.
Child 4	Child 4 carefully completes the task by carefully looking at the path of the goal and then using the pencil to get to the right path.
Child 5	Child 5 is able to draw a path and then follow the path of imagination, so that she can draw the right path and succeed.

Discussion

In this study, child 1 can pay sufficient attention and respond Head-Thigh-Toe task to measure inhibition skills of executive functions as fast as he can and get the correct respond. In sorting cards task to measure cognitive flexibility skill, child 1 can sort the cards according to the rules and requirements of tasks completely (e.g., shape or color). In working memory task, child 1 can also get good completion of mazes.

And then, child 2 has comfortable feeling for inhibition task and respond correctly in order to instruction. Child 2 can sort the cards so fast based on various criteria of cognitive flexibility task and well done the working memory task.

Child 3 can pay special attention for inhibition task. Although child 3 is the youngest child in the sample population, he can get correct respond with the help of researcher's repeated instruction. And he has sufficient sorting skills based on various criteria. In working memory task, he can also complete the mazes correctly.

Child 4 can also pay special attention and complete the inhibition task with the instruction. Child 4 can sort the cards according to the requirements of task completely and well done the working memory task.

Finally, child 5 can respond the task's instruction conveniently and pay special attention. Based on the various criteria, child 5 can sort the cards so clever. And then, she can finish the working memory task correctly.

In brief, according to the results of this study, all children can pay good respond to the all performance-based tasks of the executive functions regardless of gender or age group. It is found that young children can do well like older children and females can do well with males by the results of this study. According to the observation, reflection and performance-based tasks, child 1 has the best inhibition skills among the children so child 1 has sufficient attention and gets special support from the parents.

In cognitive flexibility task and working memory task, all children can complete the tasks correctly and conveniently because they can pay special attention, have comfortable feeling and sufficient support from their family.

Conclusion

This study followed up qualitative study and results. As a result of the study, (4-10) year-old children's executive functions start to develop and can be improved as much as they can. And then, there was no general pattern based on age or gender according to this research findings. This is an important finding because it highlights that difference in executive functions is not necessary due to age or gender. The difference could be due to individual developmental needs or personality. The finding is consistent with the results of Ashley Darcy (2014).

Chavelier et al. (2012) found the component of executive functions develops at different ages (Chavelier et al., 2012, cited in Darcy, 2014). Burrage et al. (2008) found that the development of executive functions was based on experience, not on age or gender. In a classroom, experience does play a part in children's behavior in the classroom. For example, the newer the child is to the room, the more information the child needs to be successful.

This study highlights the need for more information of executive functions, how to support children ages of four to ten as well as the need for comparative executive functions studies within other children age levels.

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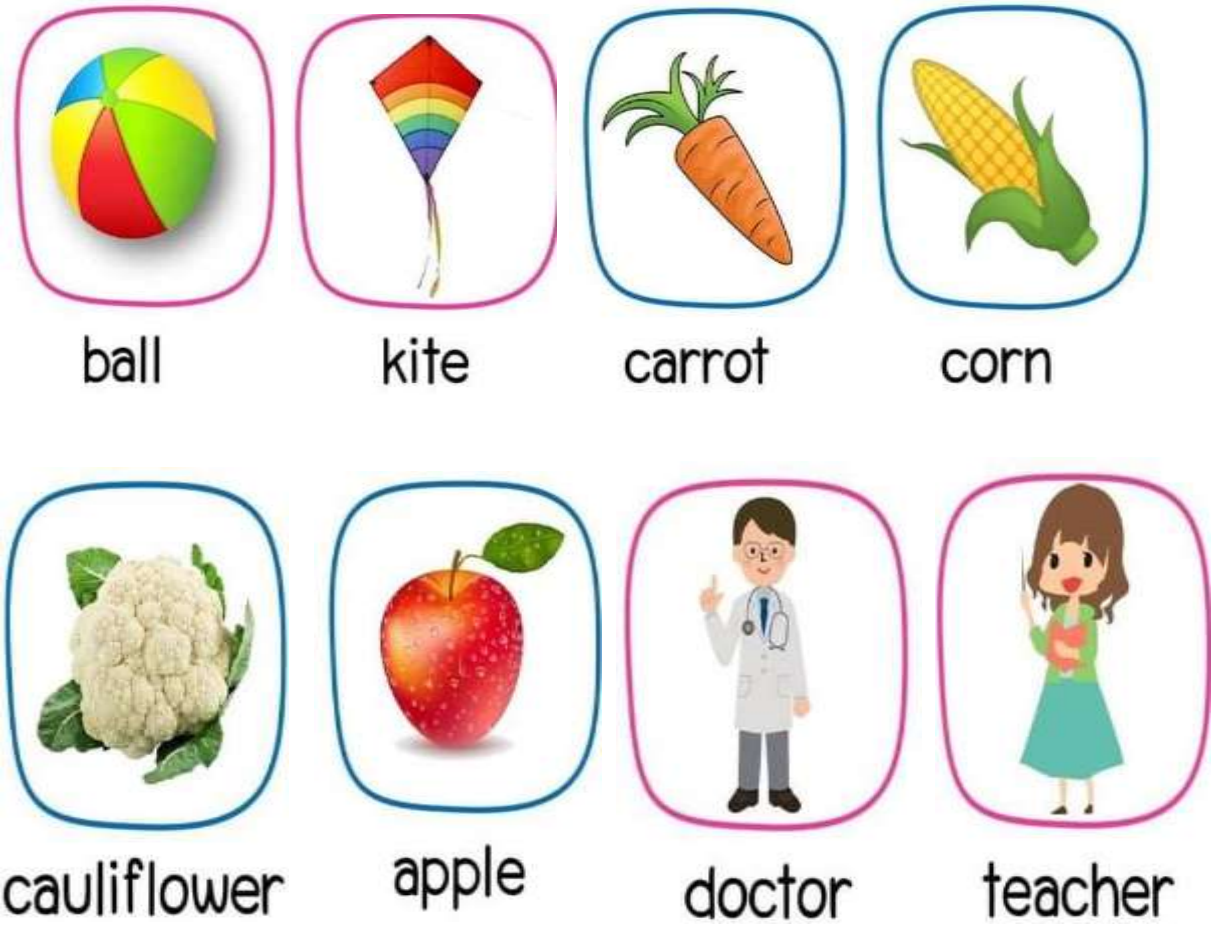
Appendix

Sample mazes to measure Cognitive Flexibility Skills



Sample cards to measure Working Memory Skills